WING-60:

INVESTIGATING WING SHAPE BASE ON COEFISIEN LIFT, COEFISIEN DRAG, ASPECT, AND TAPER RATIO

Nama Siswa 1

Aulya Dewi Nuraini, X-Olimpiade, SMA Negeri 3 Semarang

aulyadewi829@gmail.com

Nama Siswa 2

Najma Maritza Zahirah Taslim, X-Olimpiade, SMA Negeri 3 Semarang

najmaritza2704@gmail.com

Guru Pembimbing: Ridho Adi Negoro, M.Pd.

Abstract

Kebutuhan pesawat di Indonesia sangatlah meningkat, negara ini sendiri terancam kekurangan pesawat terbang. Seiringnya zaman, Indonesia juga harus mempunyai model pesawat yang berbeda. Pesawat memiliki berbagai komponen, salah satunya winglet. Winglet berpengaruh besar dalam pesawat. Pesawat memiliki banyak macam model sayapnya, ada yang memakai winglet dan ada yang tidak. Dengan sayap pesawat tidak memakai winglet dan mengubah sudut serang sayap dengan tubuh, itu lebih efektif dan lebih menghemat bahan bakar pesawat sebanyak 7%. Design sayap pesawat itu mempengaruhi besar kecilnya drag dan lift suatu pesawat. Setiap sayap pesawat pasti mempunyai sudut serangnya sendiri dengan berbagai bentuk. Oleh karena itu, pada penelitian ini diciptakan bentuk sayap pesawat dengan tipe mid wing, mono plane tanpa adanya tekukan untuk inovasi bentuk model pesawat baru.

Indonesia being the largest archipelagic country in the world means that transportation is extremely important for the people to get around, especially air transportation. By facilitating the transportation need between islands. One of the air transportation is aircraft. An aircraft has many components, one of them is a winglet. Winglet has a heavy impact on an aircraft. By the design itself could impact the drag and lift measurements of the aircraft. The purpose of this research is to establish an aircraft wing design by altering the wing angle and not using a winglet, has the title of "Wing-60". Methods that were used are the mechanic fluid method alongside the aerodynamic method. Also using a wind tunnel, lift drag sensor and airspeed sensor to find the lifting force accurately. Sriwijaya Air SJ-182 aircraft wing was the base measurements of “Wing-60”. The creation of the aircraft wing from this research is aimed to have a benefit for the air force to modify wings with the type of mid-wing, monoplane, and straight. The research from using the wind tunnel shows that the peak of the lifting force is when the aircraft is at an angle of attack of 10º and the airspeed at 17 m/s.

Keywords*: mechanic fluids, aerodynamics, winglet, drag, lift*

PENDAHULUAN

In Indonesia the need for aircraft highly increases, this country on its own is threatened by the shortage of aircraft. As time goes by, Indonesia also needs its own different aircraft wing design. An aircraft has many components, one of them is a winglet. Winglet has a heavy impact on an aircraft. By the winglet design it impacts the drag and lift measurements of the aircraft. It is also to reduce turbulence in order to change turbulence to a smaller scale and save aircraft fuel. Each aircraft wing certainly has its own angle of attack of various form. Therefore, in this research an aircraft wing design is created with a mid-wing type, monoplane without a fold to establish a better aircraft wing design.

LANDASAN TEORI

Mechanic Fluids

- Branch of science that studies the forces and movements that occur in fluids

Aerodynamics

- Branch of science that studies the movement of air, mainly when interacting with solid object.
- $P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

  Information:
  P = pressure (N/m², Pa)
  ρ = fluids density
  v = fluid flow rate (m/s)
  g = gravitational acceleration (m/s²)
  h = height (m)

Winglet

- Component of aerodynamic that is used to lessen the drag that happens on the aircraft wing.
- Intended to minimize the air vortex on the aircraft.

Wind Tunnel

- Wind tunnel are places of practice and research in the field of aerodynamics.
- The working principle of a wind tunnel is that air enters at the inlet side and then flows into a vane tube type flow straightener to reduce flow turbulence.
- The wind tunnel itself has 2 flows, laminar flow and turbulente. Turbulent or irregular flow can occur in open circuit wind tunnels due to several factors such as design, smoothness of the walls, and the influence of flow outside the circuit.
- Turbulent flow results in testing that is not optimal.

Coefficient Drag

- Drag force from an aircraft that causes the degradation in aircraft performance.
- $F_D = \frac{1}{2}\rho C_D v^2 A$
- $C_D = \frac{2FD}{\rho v^2 A}$

  Information:
  F_D = lifting force (N)
  ρ = air density (kg/m³)
  C_D = coefficient drag
  v = air speed (m/s)
  A = wing area (m²)

Coefficient Lift

- Force lift of an aircraft that causes the improvement in aircraft performance.
- Force produced from the effect of air dynamic. Acts perpendicular against relative wind through the aircraft's wing center of pressure.
- $F_L = \frac{1}{2}\rho C_L v^2 A$
- $C = \frac{2FL}{\rho v^2 A}$

  Information
  F_L = lifting force (N)
  ρ = air density (kg/m³)
  C_L = coefficient lift
  v = air speed (m/s)

A = wing area (m^2)

Aspect Ratio

- The aspect ratio is the ratio between the span and chord of the wing, meaning that the longer the wing with the same width, the greater the aspect ratio. The larger the aspect ratio, the less resistance it creates.
- $A = \frac{b^2}{A}$

  A_R = aspect ratio
  b = wing span (m)
  A = cross-sectional area of an airplane wing

Taper Ratio

- The taper ratio is the ratio of the tip chord to the root chord. The narrower the wing shape, the lower the taper ratio.
- Taper ratio has an effect on wing weight, the lower the taper ratio, the wing weight can be minimized.
- $T = \frac{ctip}{croot}$

  T_R = taper ratio
  $ctip$ = chord tip (m)
  $croot$ = chord root (m)

METODE

(1) Mechanics Fluids

Branch of science that studies the forces and movements that occur in fluids This method uses the bernoulli principle. With the use of the trial on a wind tunnel with steady state of the fluid flow. When the fluid speed increases, the static pressure will decrease and vice versa.

In this method we use the coefficient lift, coefficient drag, aspect ratio, and taper ratio formulas.

- Coefficient Lift
  Lift force of an aircraft that causes the improvement in aircraft performance.
- Coefficient Drag
  Drag force from an aircraft that causes the degradation in aircraft performance.
- Aspect Ratio
  The aspect ratio is the ratio between the span and chord of the wing, meaning that the longer the wing with the same width, the greater the aspect ratio. The larger the aspect ratio, the less resistance it creates.
- Taper Ratio
  The taper ratio is the ratio of the tip chord to the root chord. The narrower the wing shape, the lower the taper ratio.

(2) Wind Tunnel

This method uses wind tunnel to observation lift from our winglet prototype. That way we know if the winglet is effective. The wind tunnel is a test tool in the form of a tunnel, the air will be forced to travel at a predetermined speed, so that it can study the effects of the aerodynamic flow of the Wing 60. This wind tunnel uses turbulent flow which results in less regular data results.

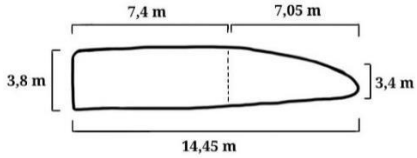
(3) Aerodynamics

Branch of science that studies the movement of air, mainly when interacting with solid object. This method uses wind tunnel to observation lift from our winglet prototype. That way we know if the winglet is effective.

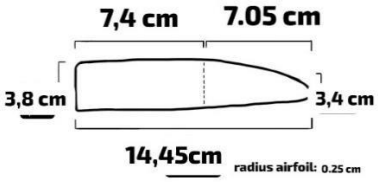
Step By Step:

- Make the prototype
  Picture 1. Find references to use the winglet size, for this research the Sriwijaya Air SJ-182 was used

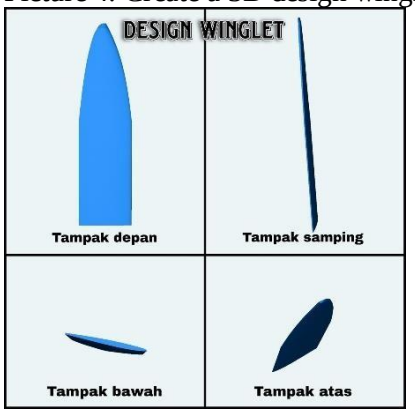
Picture 2. Determine the actual size of the actual winglet



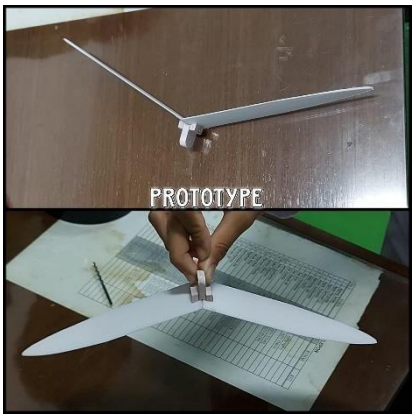
Picture 3. Determine the size of the prototype winglet using the selected scale (1:100)



Picture 4. Create a 3D design winglet



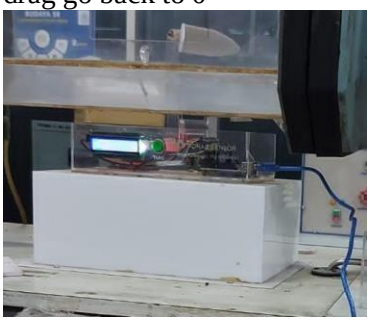
Picture 5. Print 3D design winglet



- Testing use wind tunnel

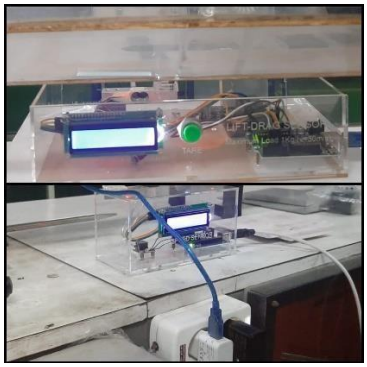
Picture 1. Turn on wind tunnel

Picture 2. Press “Tare” t make the lift and drag go back to 0



Picture 3. Set the angle of attack (0°, 10°, 15°)

Picture 4. Turn on lift drag sensor and anemometer sensor

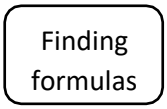


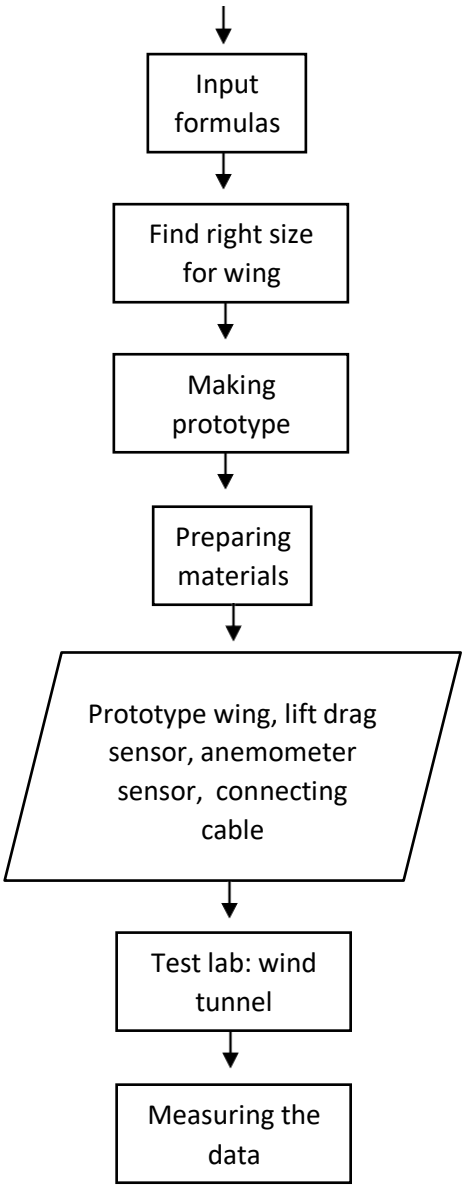
Up: Lift drag sensor
Down: Anemometer sensor

Picture 5. Observe and record data

HASIL DAN PEMBAHASAN

Hasil Penelitian





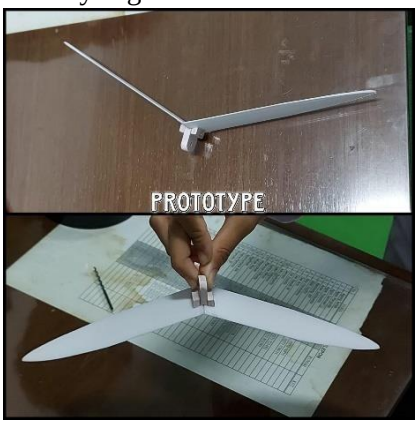
Airspeed	Angle of Attack		
	0°	**10°**	**15°**
5 m/s	4	12	13
7 m/s	7	19	22
10 m/s	12	39	43
15 m/s	27	80	88
17 m/s	34	138	117

PEMBAHASAN

Table 1. Calculation

68°	$C_D = \frac{2FD}{\rho v^2 A}$ = 0,0001407245	$C_D = \frac{2FD}{\rho v^2 A}$ = 0,0003488931

From Table 1, using 68° that is an angle of the aircraft wing. Since at this angle the value of the calculation is $\frac{CL}{C_D} = \frac{0{,}0003488931}{0{,}0001407245} =$ 2,4792633834, has a comparative value lower than 2,5. With that angle the aircraft will have a sturdy flight in the air.



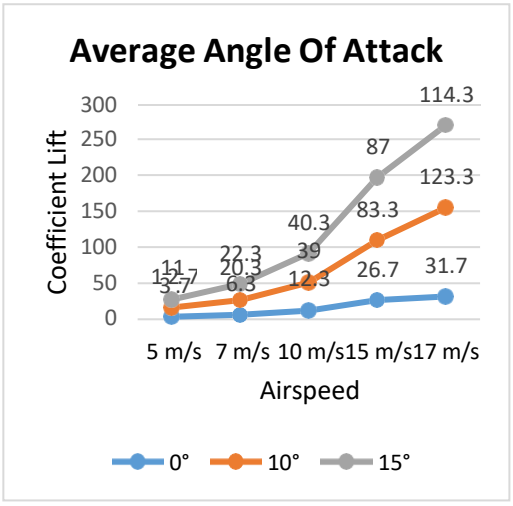
Picture 1. Prototype Wing

Picture 1, is our prototype Wing-60 that we have made using formula that we have. With the angle of attack 68° for each wing, and the total of angle of attack is 136° for each aircraft.

The angle of attack of wing design will have an impact on an aircraft, especially to save aircraft fuel. We want to investigate our wing design, Wing-60 with different angle of attack and shapes than before.

We testing 3 times through wind tunnel, and average the results, and this table and graph we got.

Table 2. Average Angle Of Attack



Graph 1. Average Angle Of Attack

From the results three experiment data of Table 2 and Graph 1, shows that the top of the graph of the lift force when the plane is at an angle of attack 10° and the airspeed in 17 m/s.

In Table 2 and Graph 1 it can be seen that at angle of attack 10°and the airspeed 17 m/s it produces 123,3 average lift force, it has the highest value. With angle of attack 10° and airspeed 17 m/s, it shows that are at the top of the lift force.

Conclusion

- "Wing-60" effective and efficient total angle of attack 136°.
- The development succeed of an aircraft wing based on coefficient lift, aspect, and taper ratio.
- The peak angle of attack aircraft on 10° and airspeed 17 m/s.
- The best lift coefficient value for winglet is 0.0003488931 with an angle of attack 10° and produces average lift 123,3 in 17 m/s.

SIMPULAN DAN SARAN

- The calculation results using the aspect ratio and taper ratio formula. As component of the formulas known, b has the amount of 14,45 m, A has the amount of 52,7 m², $ctip$ has the amount of 3,4 m, and $croot$ has the amount of 3,8 m.

- Based on Table 2. Calculation, the calculation results using the coefficient drag and coefficient lift formula. As component of the formulas known, ρ has the amount of 1,2 kg/m³, v has the amount of 220,833 m/s, A has the amount of 52,7 m², and *FR* has the amount of 580 N.
- Based on our calculation, using 68° that is an angle of the aircraft wing. Since at this angle the value of the calculation is $\frac{c_L}{C_D} = \frac{0,0003488931}{0,0001407245} = 2,4792633834$, has a comparative value lower than 2,5. With that angle the aircraft will have a sturdy flight in the air.
- With the effective angle of the aircraft wing model known which is 68° with the total of both wing 136°, a prototype was made. Using a wind tunnel and drag & lift sensors, the lift of the prototype was tested. The test was carried out by comparing 3 types of angles of attack (aoa), namely 0°, 10°, 15° and different airspeed. Obtained 3 trials with 5 airspeed/trial. (insert table; first test, second test, third test. Chart; 1,2,3,4)

DAFTAR PUSTAKA

aeroengineering.co.id. Konfigurasi Sayap Pesawat (High-wing, Mid-Wing, Low-Wing).

Arifannisa, Nabila. 2011. Gaya Angkat Pesawat Terbang.

Barus, Michael Bastanta, Radi, Budi. 2022. Kaji Komputasional Struktur Pesawat Model Wing in Ground Effect Tipe Sayap Tandem

Budiaman, Budi. 2019. Sayap Pesawat Terbang.

cnbcindonesia.com. 2022. Diam-Diam RI Terancam 'Kiamat' Pesawat Terbang, Kok Bisa?

Digilib Polman. Bab II - Tinjauan Pustaka, Gaya-Gaya pada Pesawat.

Dirgantara Indonesia. 2023. Aerospace.Fitrikananda, Bona P. 2020. Studi Pengembangan dan Pemanfaatan Winglet untuk Meningkatkan Performansi Pesawat.

Ghurri, Ainul. 2014. Dasar-Dasar Mekanika Fluida.

Hegade, K. P. Nariya. 2020. Design and study of mini wind tunnel for microsystems fluid interaction under low Reynolds number flows.

Kurniawan, Andre. 2021. Mengapa Ujung Sayap Pesawat Bentuknya Melengkung? Begini Alasannya...

Irawan. Yosua Heru. 2019. Drag and Lift.

Laskito, Irfan. 2020. Ini Armada Pesawat Yang Dimiliki Garuda.

Naufal, Wega Fawwaz. Prof. Ir. Sutrisno, MSME., Ph.D. 2019. Studi Numerik Aliran Fluida Sekitar PesawatChengdu J-10 Dengan Sayap SAAB JAS-39 Gripen Terhadap Berbagai Sudut Serang.

Project.B Engineering, Aviation and Automotive. Konfigurasi Sayap Pesawat (Wings Configuration).

Purwanto, Hengki, dkk. 2022. Rekayasa Kecepatan Angin Wind Tunnel dan Gerak Wings pada

Aerodinamika Berbasis Alat Ukur Anemometer.

Rahmawan, Exwan, Gaguk. 2017. Analisis Kestabilan Aerodinamika Pada Rudder Pesawat Terbang N2XX Pada Kondisi Left Engine Inoperatif (LEI).

Reza, Reza, Bona P Fotrikananda. 2020. Airbleed Indicator Faultilluminate Akibat Gangguan Pada Pressure Regulator Pada Sistem De-Icing Pesawat Air 42-500.

Saputra, Awal, Eddy, Isa, Lenny, Devi. 2016. Modifikasi Airfoil Sayap Pesawat Conceptual Transport RM-001.

Siregar, James, Dedy Syarif Qusyairi. 2020. Rancang Bangun Simulasi Pergerakan High Lift Device pada Pesawat.

Soemaryanto, Arifin Rasyadi, Heru Sandi. 2017. Pengaruh Perangkat Winglet Pada Sayap Pesawat Nirawak Konfigurasi Twin Taailboom Pusher Terhadap Prestasi Terbang Jelajah.

Sorangang, Tommy. 2021. Sriwijaya SJ-182 Merupakan Seri Boeing 737 Varian Terpendek.

Sormin, Muhammad Randy, Rosyida Permatasari. 2020. Analisis Spiroid Winglet Pada Pesawat Subsonic Dengan Variasi Sudut Serang Terhadap Konsumsi Bahan Bakar Menggunakan Metode Computational Fluid Dynamic.

Stefphanie Christin. INST-06: PENGEMBANGAN DESAIN TEROWONGAN ANGIN

SEDERHAN

STEM. Winglet: Perangkat Peningkat Efisiensi Bahan Bakar pada Pesawat Terbang.

Triani, Suciari, Moh. Ardi, Lazuardy R. Structure Analysis and Manufacturing Of Wings Trainer-5574.

UNKRIS. Aerodinamika.

Universitas Pattimura. 2022. Peranan Ilmu Matematika dalam Menjawab Tantangan Bangsa yang Semakin Kompleks dan Dinamis di Era Revolusi Industri 4.0.

Yogatama, Marga, Ramon Trisno. 2018. Studi Koefisien Drag Aerodinamika pada Model Ahmed Body Terbaik Berbasis Metode Numerik.

Zulianto, Moh., Indra Herlamba Siregar. 2019. Uji Eksperimen Model Turbin Angin Swirling Savonius Dengan Deflektor Diam Menggunakan Terowongan Angin.